

ACTIVITY REPORT

2019

INNOVATING
FOR ENERGY

IFP ENERGIES NOUVELLES



OUR MISSION

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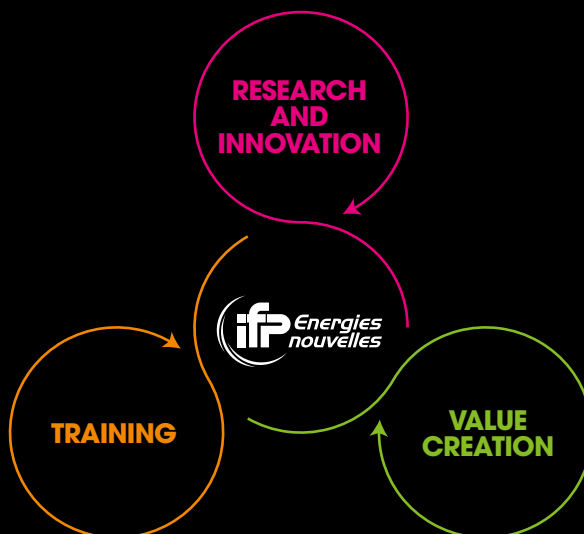
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A CONTEXT

CLIMATE CHANGE AND THE ENERGY TRANSITION



THREE PRIORITY AREAS



IFP Energies nouvelles

is a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities, structured around three strategic priorities: sustainable mobility, new energies and responsible oil and gas.

AS PART OF THE PUBLIC-INTEREST MISSION WITH WHICH IT HAS BEEN TASKED BY THE PUBLIC AUTHORITIES, IFPEN FOCUSES ON:

- > providing solutions to take up the challenges facing society in terms of energy and the climate, promoting the transition towards sustainable mobility and the emergence of a more diversified energy mix;
- > creating wealth and jobs by supporting French and European economic activity, and the competitiveness of related industrial sectors.

An integral part of IFPEN, its graduate engineering school – IFP School – prepares future generations to take up these challenges.

PUBLIC/PRIVATE FUNDING

IFPEN has proven expertise across the entire value chain, from fundamental research to innovation. It is funded both by a state budget and by its own resources provided by industrial partners. The latter account for over 50% of IFPEN's total budget, a configuration that is almost unique in France.

INNOVATION-DRIVEN RESEARCH

The aim of IFPEN's R&I programs is to overcome existing scientific and technological challenges in order to develop innovations that can be used by industry.

FUNDAMENTAL RESEARCH, THE BUILDING BLOCK FOR FUTURE INNOVATION

IFPEN's fundamental research program aims to create a bedrock of knowledge essential for the development of innovations. The scientific expertise of IFPEN's researchers is internationally recognized and they are regularly consulted by the public authorities to provide their insight in their specific fields to inform the decision-making process.

THE CREATION OF WEALTH AND JOBS

IFPEN's economic model is based on the transfer to industry of the technologies developed by its researchers. This technology transfer to industry generates jobs and business, fostering the economic development of fields and approaches related to the mobility, energy and eco-industry sectors. IFPEN's innovations are brought to market through close partnerships with industrial players and IFP Group subsidiaries. In both emerging and mature markets, IFPEN creates companies or acquires stakeholdings in companies of significant potential, either directly or via capital funds. In addition, and as part of collaboration agreements, IFPEN supports the development of SMEs and SMLs which in turn benefit from its technical and legal expertise.

INTERNATIONAL SCOPE

IFPEN is an active player in numerous projects, technological platforms and networks within the context of the European Horizon 2020 Framework Program, and is contributing to the emergence of a European vision of research in the fields of mobility and energy. IFPEN works with over 100 academic and industrial partners, international companies and SMEs around the globe, through collaborative projects, consortiums or bilateral contracts.

TRAINING, A VECTOR FOR COMPETITIVENESS

Against the backdrop of the energy transition, IFP School and IFP Training provide industry with the highly qualified personnel it requires to take up current and future technological, economic and environmental challenges. IFP School operates within a highly international environment and provides young graduate engineers with advanced graduate programs in the fields of energy, motor vehicles and the environment. Over 500 students from throughout the world graduate from IFP School each year. IFP Training, an IFPEN subsidiary, offers training courses to almost 15,000 employees from industry every year, securing their competitiveness.

2019

IFPEN DRIVING INNOVATION

INTERVIEW WITH **DIDIER HOUSSIN**

Chairman and CEO of IFPEN



A fundamental transformation to address the new challenges associated with the energy transition and sustainable mobility.



A fundamental transformation of the energy sector is under way today to address the challenge of climate change.

IFPEN – resolutely committed to innovation to underpin a sustainable energy mix – supports these ambitions. Accordingly, in 2019 – a year marked by advances in a number of areas – we adjusted our research perimeter, with a reinforcement of activities relating to sustainable mobility and new energies.

In the field of sustainable mobility, IFPEN is developing innovative technologies for powertrain electrification, from electric machines to battery characterization and simulation. Similarly, our connected mobility research is bringing solutions both for consumers seeking to analyze their eco-mobility and for local authorities, to support their urban infrastructure design projects.

Other developments at IFPEN included the signing of a strategic partnership agreement with Total group for CO₂ capture, storage and utilization, the ramping-up of our offshore wind power activities, a reinforced positioning in the field of energy storage and the development of digital technologies to support the energy transition.

In addition, in order to address society's growing expectations concerning the elimination of plastic waste, in 2019 IFPEN introduced a specific program dedicated to the development of chemical recycling processes, with very encouraging initial results on a pilot scale.

In 2019, in order to further strengthen its position in the innovation ecosystem, IFPEN applied for a second Carnot label, relating to its energy resources activities. This new label, awarded in 2020, as well as the renewal of the IFPEN Transports Energie Carnot Institute, reflect the quality of our expertise and commitment to supporting the energy transition, our capacity to mobilize the highest level of scientific know-how to drive innovation, our ability to transfer our skills to industry through partnerships with companies and, in particular, SMEs.



I must emphasize that this dynamic environment is underpinned by the internal actions implemented by IFPEN to stimulate innovation. A project incubator encourages the emergence of disruptive innovations in new fields. An internal innovation challenge – the second edition of which was held in 2019 – focuses on new energy markets.

A transformation process is also under way at IFP School, as it introduces changes to its teaching programs to reflect industry's requirements in the fields of energy innovation and sustainable mobility.

Hence, through fundamental research aimed at overcoming existing scientific challenges, through applied research, through the industrial development of R&I results and through training leading to qualifications, IFPEN is committed to supporting the energy transition by offering innovative, sustainable and cost-effective solutions.

At a time when my current mandate will soon end and when preparations for our new objectives and performance contract for the period 2021–2026 are set to begin, I would like to reaffirm my full confidence in the commitment of IFPEN's employees to accelerating our transformation process and meeting the energy transition challenge.

I hope you enjoy reading this report!

On 2 June 2020, Pierre-Franck Chevet was appointed Chairman and CEO of IFP Energies nouvelles.

CORPORATE GOVERNANCE

THE EXECUTIVE COMMITTEE*

GENERAL MANAGEMENT

1 Pierre-Franck Chevet

Chairman and CEO

2 Catherine Rivière

Executive Vice-President
Research and Innovation

3 Éric Lafargue

Executive Vice-President
Administration and
Management of Subsidiaries



BUSINESS UNIT DIRECTORS

4 Éric Heintzé

Energy Resources

5 Jean-Pierre Burzynski

Processes

6 Gaëtan Monnier

Transport

7 Christine Travers

Education and Training

8 Nathalie Alazard-Toux

Industrial Development



OTHER MEMBER OF THE EXECUTIVE COMMITTEE

9 Véronique Ruffier-Meray

Human Resources Director



* As of 2 June 2020

THE BOARD OF DIRECTORS*

STATE REPRESENTATIVES

Pierre-Franck Chevet

Chairman and CEO

Frédéric Ravel

Scientific Director of the "Energy, Sustainable Development, Chemistry and Processes" sector at the Research and Innovation Strategy Service at the General Directorate for Research and Innovation, representing the Minister of Research

Alicia Saoudi

Head of the unit in charge of Energy, State Holdings, Industry and Innovation, French Budget Office

Marie-Solange Tissier

President of the Regulation-Resources section at the High Council for the Economy, Industry, Energy and Technology, representing the Minister of Industry

QUALIFIED MEMBERS

Monique Axelos

Scientific Director Food and Bioeconomy, INRAE

François Dassa

Director Prospective and International Affairs, EDF

Carla Gohin

Director of Research, Innovation and Advanced Technologies of PSA Group

Didier Holleaux

Executive Vice President, ENGIE

Helle Kristoffersen

President Strategy-Innovation – Total

Hervé Le Treut

Member of the Académie des sciences (French Academy of Sciences), Director of Research at the CNRS (French National Center for Scientific Research)

Sophie Paturle-Guesnerot

Managing Partner of Demeter-Partners

Axel Plasse

Deputy-Director, Powertrain Development Strategy, Renault-Nissan-Mitsubishi Alliance

Valérie Quiniou-Ramus

Executive Director for Prospective and Research, ADEME

Bruno Sportisse

CEO, INRIA

STAFF REPRESENTATIVES

Laurent Duval

Sylvie Perrin

WITH THE ATTENDANCE OF

Cyril Bouyeure

Economic and Financial General Controller, Ministry of the Economy

Philippe Geiger

Deputy Director of Energy, Ministry for Ecological and Inclusive Transition

Guillaume Gougeul

Secretary of the Central Works Committee

*As of 10 July 2020

THE SCIENTIFIC BOARD*

Grégoire Allaire

Chairman of IFPEN's Scientific Board, Professor of Applied Mathematics at the École polytechnique, Senior University Professor

Carmen Claver

Professor of Inorganic Chemistry at Rovira i Virgili University, Tarragona

Christophe Coperet

Professor of Molecular Chemistry and holder of the surface and interface chemistry chair at the École polytechnique fédérale, Zürich

Marc-Olivier Coppens

Ramsay Memorial Professor and Head of the Chemical Engineering Department at University College London (UCL)

Patrick Criqui

Director of research at the CNRS, head of the Sustainable Development and Energy Economy team at the GAEL Laboratory of the CNRS and Grenoble-Alpes University

Luigi Del Re

Professor at Johannes Kepler University, Linz, Head of the Institute for Design and Control of Mechatronic Systems

Sylvie Dequin

Head of the INRA Division Microbiology and the Food Chain (MICA)

Jocelyne Erhel

Director of Research at INRIA (French Institute for Research in Computer Science and Automation)

Mohamed Gabsi

Professor and Head of the Electronics-Electrical Engineering Department at the École normale supérieure de Paris-Saclay

Anke Lindner

Professor of Physics at Paris Diderot University and Researcher at the Physics and Mechanics of Heterogeneous Media Laboratory at the ESPCI Engineering School, Paris

Jean-François Minster

President of the Île-de-France Photovoltaic Institute

Christine Rousselle

Professor of Combustion and Optical Diagnostics at Orléans University, Delegate at IEA Clean and Efficient Combustion TCP

Marc Schoenauer

Principal Senior Researcher with INRIA Saclay, co-head of the TAO/TAU team

Luc Vervisch

University Professor at the Institute of Applied Sciences (INSA), Rouen

Sophie Violette

Professor of hydrogeology at Sorbonne University & Head deputy of the Laboratory of Geology, ENS-PSL

* As of 16 June 2020

IFPEN 2019 NEWS IN BRIEF



SUCCESS FOR IFPEN'S ENERGY INNOVATION EVENTS

IFPEN's Energy Innovation events, inaugurated in 2019, hosted three round tables in Paris over the course of the year: the theme of the first of these was "transport electrification: what potential for what uses?". Grenoble-Alpes Métropole, ADEME and Enedis took part in the session. The second such event focused on the future of second-generation (2G) biofuels, also known as "advanced biofuels". The French Ministry for the Ecological and Inclusive Transition, Safran and the Innovations Institute in Ecomaterials, Ecoproducts and Ecoenergies (Canada) were present at the event. Finally, the third edition, dedicated to CO₂ capture, storage and utilization, brought together the IEA, Air Liquide and Total.

Around one hundred people, including numerous journalists, attended these events hosted by IFPEN. Further IFPEN events will be organized in 2020.

To follow the events on Twitter:
#RDVifpen



HYDROGEN IN THE ENERGY TRANSITION: IFPEN PROVIDES ITS EXPERTISE

On 6 June 2019, within the context of the board of inquiry on the economic, industrial and environmental impact of renewable energies, IFPEN came before the French National Assembly to present the role of hydrogen in the energy transition, the associated production methods and costs as well as the conditions for its deployment. Questions relating to the use of hydrogen in the transport sector and its role in the energy mix were also tackled.

In addition, on 27 June, a preliminary study jointly conducted by Sintef (a Norwegian research center) and IFPEN was presented in Brussels at the Hydrogen for Europe workshop, organized by the IOGP. This preliminary study, carried out as part of the reflection process concerning actions to be implemented to comply with the undertakings specified in the Paris Agreement, evaluates hydrogen's potential in Europe. It takes stock of the potential role of hydrogen produced from natural gas and decarbonized by CCS.

An in-depth study on the strategic role of hydrogen to make it a pillar of Europe's energy transition is currently under development.



Find out more.

IFPEN RESEARCHERS GO OUT TO MEET SCHOOL PUPILS AND THE PUBLIC

In May 2019, researchers from IFPEN went out to schools in Rueil-Malmaison to raise pupils' awareness of air pollution related to human activity. Interactive presentations gave pupils the opportunity to immerse themselves in the subject, tackling the themes of greenhouse gases and mobility. And in October, as part of the French Science Festival, IFPEN joined forces with 13 other research organizations at the Forum des Halles in Paris to present "Science en Direct", a public event providing an original and entertaining take on the themes of energy, the environment, climate, space, biodiversity and health.



Video: French Science Festival: watch IFPEN researchers (only in French).

BIOECONOMICS, BIOTECHNOLOGIES, SOILS: INRAE AND IFPEN RENEW THEIR AGREEMENT

In April 2019, Philippe Mauguin, Chairman and CEO of INRAE, and Didier Houssin, Chairman and CEO of IFPEN renewed the partnership agreement between the two organizations for a period of five years. The priority themes for this collaboration relate to the mobilization of biomass for bioeconomics, biotechnologies and the contribution of soils to the mitigation of climate change.



Find out more (only in French).



IFP SCHOOL: ACCREDITATIONS TO AWARD QUALIFICATIONS

In September 2019, the French National Engineering Accreditation Board renewed IFP School's accreditation to award specialized engineering degrees for a period of five years (the maximum period). The accreditation covers all ten engineering degrees awarded by the school. In January 2019, the French Ministry for Higher Education, Research and Innovation had also issued a decree granting IFP School the right to award Master's-level applied graduate degrees. These two qualifications cover all of the school's student profiles.



CHANGING MOBILITY IN THE ÎLE-DE-FRANCE REGION: IFPEN IS COMMITTED

In October, the “Construire au futur, habiter le futur” (Build the future, live the future) program, promoted by the Île-de-France region, was designated winner of the French “Innovation Territories” call for projects. It brings together 120 players, including IFPEN, as a partner on the theme of digital technology for sustainable towns, cities and territories. Research concerning the introduction of tools designed to collect mobility data across the Paris-Ouest la Défense (POLD) region, such as Geco air™, will be conducted by IFPEN.

Another highlight of the year was the approval of the Île-de-France region’s “Convertissons la mobilité” (Let’s change mobility) bicycle plan, coordinated by IFPEN and conducted in partnership with POLD and start-ups Geovelo, K-Ryole and Galanck. The aim of this regional bicycle plan is to provide users with a concrete and global response to help them switch to the widespread use of bikes.



IFPEN, A KEY PLAYER IN THE LYON AREA

On 22 May 2019, at the “Transition énergétique : les entreprises sont en action !” (Energy Transition: businesses are mobilized!) conference, organized by MEDEF Auvergne-Rhône-Alpes, Cécile Barrère-Tricca, IFPEN-Lyon site director, was interviewed at the start of a round table dedicated to sustainable mobility. After reminding those present of the historical importance of the transport sector in the region’s economic development, she outlined the current main challenges: reduction in pollutant emissions, diversification of energy sources and adaptation to evolving transport modes. Using a few examples, she went on to demonstrate how economic players in Auvergne-Rhône-Alpes are working in partnership with IFPEN to explore different solutions, including the optimized use of low-carbon fuels and the development of electric and connected vehicles.

Cécile Barrère-Tricca also spoke at an event organized in Paris on 3 December at the instigation of David Kimelfeld, President of Lyon Metropolis, to promote the economic appeal of Lyon and the surrounding region to a panel of industrial players. The event, which brought together around thirty representatives of major groups and start-ups, was an opportunity to present IFPEN’s role and deeply-rooted position in a regional ecosystem ideal for nurturing innovation.



Video: watch Cécile Barrère-Tricca speaking on 22 May 2019 on the Medef Auvergne-Rhône-Alpes YouTube channel (only in French).

TWO CARNOT INSTITUTES WITHIN IFPEN!

In addition to the renewal of the IFPEN Transports Energie Carnot Institute, the French Ministry for Higher Education, Research and Innovation announced that IFPEN had been awarded a new Carnot label relating to its energy resources activities.

The IFPEN Transports Energie Carnot Institute coordinates Carnauto, dedicated to the vehicle and mobility sector. It contributes to AirCar, dedicated to aviation, as well as to collaborative structures specializing in technological research and innovation, bringing together industrial players. The IFPEN Transports Energie Carnot Institute is also a founding member of two competitiveness clusters, Cara (urban mobility and public and goods transport systems) and Mov'eo (environmentally-friendly cars and public transport), an active member of the ASTech cluster (aviation and space) and a member of the Vedecom energy transition institute (mobility).

The role of the new IFPEN Ressources Énergétiques Carnot Institute, which brings together 14 laboratories, is to address scientific, technological and digital challenges in order to support the transition to a low-carbon energy mix. To do so, it has defined three objectives: develop renewable energies focusing on wind power, energy storage and geothermal energy, minimize the "climate risk" associated with industrial activities, via the reduction in CO₂ emissions and a better understanding of climate/ground interactions, and support its partners in the oil and gas industry and service sector as they seek to address the challenges of the energy transition while minimizing exploration and production risks.



THE FRENCH MINISTER FOR THE ECOLOGICAL AND INCLUSIVE TRANSITION VISITS IFPEN-LYON

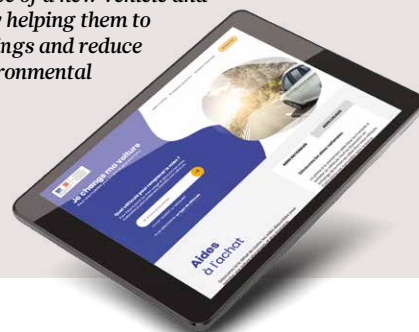
François de Rugy, Minister of State, Minister for the Ecological and Inclusive Transition, Emmanuel Aubry, Prefect of Auvergne-Rhône-Alpes region and of the Rhône, Jean-Luc Fugit, Member of Parliament for the Rhône and Chairman of the French National Air Council, and Yves Blein, Member of Parliament for the Rhône, visited IFPEN-Lyon on 1st March. The event was an opportunity for IFPEN to present its research supporting sustainable mobility and new energies.

During the visit, the Minister made Cécile Barrère-Tricca a Knight of the French National Order of Merit.



JECHANGEMAVOITURE.GOUV.FR

In 2019, the French Ministry for the Ecological and Inclusive Transition launched the jechangemavoiture.gouv.fr platform, for which the calculation core was developed by IFPEN's teams. Aimed at the general public, the site allows people to compare several vehicles of varying degrees of electrification on the basis of their own particular mobility usages, guiding them in their choice of a new vehicle and ultimately helping them to make savings and reduce their environmental footprint.



KEY FIGURES

(end of 2019)

185

patent applications, including 94 in the field of new energy technologies



More than 600

scientific publications and conference papers



Around 500

IFP School graduates



ISO

9001 certified for R&I activities



26,000

participants, from 130 countries, enrolled on IFP School's MOOC on the energy transition



38

contractual research projects involving international partners, of the 71 launched in 2019



SOCIAL AND FINANCIAL DATA

SOCIAL DATA

To address the national priorities concerning the energy transition, making efficient use of the company's resources is an objective that depends on the implementation of a dynamic human resources policy. This policy makes the identification and anticipation of the skills required to develop high-level scientific and technical expertise a priority.



1,633 

Total full-time equivalent workforce for 2019

including **1,136** researchers

Nearly 200 research grant holders, post-doctoral researchers and placement students



400

mobile employees over the past 4 years



91%

of employees benefited from at least one training initiative in the year



4.7%

Percentage of employees with a disability



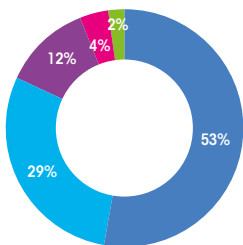
FINANCIAL DATA

IFPEN's own resources continued to grow in 2019, driven by the increase in dividends from its subsidiary Axens. In parallel, the increase in operating expenses remained contained, primarily resulting from accounting items with no impact on cash-flow (depreciation on investments and other provisions).

Globally, personnel and operating costs have been stable over the past two years, which has not hampered the ongoing redeployment of some upstream oil R&I activities to new energy technologies.

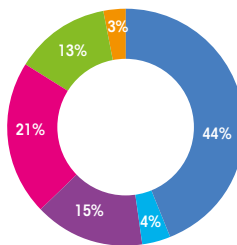
For example, the self-funding of oil and gas activities was reinforced in 2019. These activities now generate a net income and since 1st January 2019 have supplemented IFPEN's budget allocation fully dedicated to new energy technology activities.

**BREAKDOWN OF
OPERATING EXPENSES**
Financial end 2019



■ Personnel costs
■ Operating costs
■ Amortization, provisions
■ Taxes
■ Other

**BREAKDOWN OF
OPERATING REVENUE**
Financial end 2019



■ Net budget allocation
■ Royalties
■ Public funds
■ Services and collaborative research
■ Dividends
■ Other

€283.3 million
Operating expenses
including **€236.2 million**
for R&I

€124.5 million
Budget allocation

€156.1 million
**Own resources (excluding royalties
for third party accounts)**

60%
**of budget
dedicated to NETs**

WEIGHT OF NETS IN IFPEN R&I IN 2019	%
Total NETs	60
New energies	21
Sustainable mobility	18
Cross-disciplinary fundamental research	21

SUSTAINABLE MOBILITY

Taking into account evolving transport modes, boosting energy efficiency in transport and diversifying energy sources are the major challenges associated with sustainable mobility. IFPEN's researchers are channeling their expertise into addressing these challenges to come up with innovations (products and services) that can be exploited by industry, are competitive from an economic, energy and environmental point of view, and are useful to the community and citizens, among others.

Three complementary themes are being explored:

- electric mobility, from the hybrid vehicle to fully electric;
- connected mobility, with the development of services and applications;
- mobility with a low environmental impact, with the improvement of IC engines in a context of hybridization and the optimization of fuel use, particularly low-carbon.

The IFPEN Transports Energie Carnot Institute

Since 2006, IFPEN's activities in the field of transport have been conducted within the framework of the IFPEN Transports Energie Carnot Institute (IFPEN TE). Renewed in 2020 for a period of four years by the ANR, this label is a recognition of the IFPEN TE Carnot Institute's capacity to support its industrial partners (major groups, intermediate-sized companies, SMEs, micro-companies and start-ups) within the context of collaborative research activities or services, and develop products and software solutions, backed by an ecosystem of innovative partner companies.



Supporting vehicle electrification

To help accelerate transport electrification and develop optimized and energy-efficient electrical systems, IFPEN's teams are working on several aspects:

- batteries: understanding aging and malfunctions, improving system behavior, new generations and recycling;
- electric machines and innovative hybrid systems, as well as their power and control electronics;
- effortless load transport.

Waste thermal energy recovery solutions, based on the Organic Rankine Cycle (ORC), have also been developed – particularly within the framework of the partnership with SME Enogia – that contribute to the overall improvement of powertrain energy efficiency.

With more than ten years' experience in the research, characterization and modeling of electrochemical storage systems for transport, IFPEN is today recognized as a leading player in the field. IFPEN's successful positioning in this sector is such that it has been able to join forces with members of the European Battery Alliance to study and model advanced battery systems, via the European H2020 MODALIS² project. Its battery modeling research is also a springboard to innovations in themes of current interest, such as rapid charging and the second life of batteries.

In 2019, IFPEN's teams also pursued their work in the field of system behavior, as well as aging and thermal runaway mechanisms of batteries, a major challenge in terms of ensuring the safety and maintaining the performance of electric vehicles (H2020 DEMOBASE project). Their models are available in the Electric Storage library of the Simcenter Amesim platform marketed by Siemens Digital Industries Software.

IFPEN also offers an electric machine technology covering the needs of all hybrid vehicle and electric vehicle market segments.

In addition, IFPEN has acquired a new electric vehicle test bench and a new electric motor test bench in order to reinforce its R&I provisions and services in the field of electric mobility.

HIGHLIGHT

LAUNCH OF THE MODALIS² PROJECT FOR THE MODELING OF ADVANCED BATTERIES

In 2019, via the IFPEN Transports Energie Carnot Institute, IFPEN led the MODALIS² project for the "Advanced Batteries" call for proposals within the Horizon 2020 program. This project brings together Saft, Siemens Digital Industries Software, Siemens Corporate Technologies, Umicore, Solvay, K&S, CRF, Gemmate Technologies and the University of Turin, alongside IFPEN. MODALIS² is aimed at developing a chain of numerical tools for the purposes of modeling and designing battery systems using new materials. This research will support the development of advanced battery systems while optimizing development and production costs.



In 2019, IFPEN's teams also developed their know-how and expertise in the field of electric machines to support other applications, such as effortless load transport. For example, IFPEN joined forces with SME K-Ryole for the effortless transport of heavy loads (of up to 250 kg) by bicycle or on foot. IFPEN is also leading the Île-de-France region's "Convertissons la mobilité des Franciliens vers le vélo" (Let's convert residents of the Île-de-France region into cyclists) project, which has involved full-scale tests of these trailers.



HIGHLIGHT

ELECTRIC BICYCLE BATTERY RECYCLING

IFPEN is working in partnership with start-up company Doctibike on electric bicycle battery recycling within the framework of the Energyk project financed by the Auvergne-Rhône-Alpes region. The aim of this project is to develop battery packs for electric bicycles that can be dismantled, are communicating and can be easily reused.



**BERTRAND LECOINE**

IFPEN project manager

IFPEN'S EXPERTISE APPLIED TO OTHER FIELDS, SUCH AS MOBILITY IN HOSPITALS

"For the last internal innovation challenge, I proposed a removable support solution for transporting heavy wheeled loads to make life easier for hospital porters."

From genesis to proof of concept, all those involved at IFPEN rallied together, continuing to demonstrate the agility and pragmatism synonymous with this challenge. The proposed solution was developed thanks to a combination of mechanical know-how and expertise in the control of electric powertrains adapted to load elimination. Drawing on the broad range of expertise present at IFPEN, researchers also pondered appropriate alternative applications, leading to the opening-up of new market opportunities in the hospital sector. After the winning proposal in mid-2018 and the proof of concept in 2019, industrialization is set for 2020."

Supporting connected mobility

For several years, researchers at IFPEN have been exploiting the potential offered by digital technology to reduce the environmental impact of transport, proposing web services and applications for connected vehicles, from eco-driving to the evaluation of pollutant emissions, via energy analysis, for the benefit of citizens, local authorities and businesses.

Supported by the Geco air™ application, various experiments are under way to measure and understand the impact of urban infrastructure on vehicle pollution, within the framework of several regional projects, such as AirMap (Grand Est), Airmès (Provence-Alpes-Côte d'Azur) and ReVeAL (Auvergne-Rhône-Alpes). For example, Geco air™ facilitates local authority decision-making concerning urban planning, road development and traffic management. The new version of Geco air™ now helps companies draw up their mobility plans.

IFPEN's teams are also contributing their expertise in the field of algorithm control and development within the framework of several European projects, supporting the development of eco-routing connected services, to identify the fastest, most fuel-efficient route, and eco-driving connected services to reinforce the reduction in fuel consumption. For example, in the OPTEMUS project, which was completed in 2019, real-use tests conducted in an urban environment demonstrated fuel savings of more than 10% combined with reduced journey times. Similar initiatives are being conducted within the H2020 CEVOLVER project or will be conducted within the H2020 LONGRUN project dedicated to heavy trucks, accepted at the end of 2019 and launched at the start of 2020.



**HIGHLIGHT****AN ONBOARD KIT TO MEASURE REAL-TIME POLLUTANTS**

In 2018, IFPEN joined forces with the SME Capelec to begin the development of REAL-e, a smart and connected onboard analyzer that measures real-time pollutant emissions from the exhaust of light vehicles. REAL-e is a simpler, more economical and faster system than those currently employed. In 2019, REAL-e won one of the three “Coups de cœur” (jury’s favorite) innovation awards at the Equip Auto tradeshow (dedicated to automotive after-sales and mobility services) in Paris.

Improving IC powertrains

In a context of the tightening-up of regulations and despite increasing vehicle hybridization, further improvements to IC engines are required. IFPEN’s teams thus continue to conduct research activities targeting IC engines with a view to reducing fuel consumption and pollutant emissions. The optimized use of low-carbon fuels makes it possible to further reinforce the environmental benefit of these disruptive technologies.

IFPEN is a major contributor to several projects conducted within this field as part of the H2020 program. For example, the EAGLE project, led by IFPEN, is aimed at developing a gasoline powertrain for a hybrid vehicle with a peak efficiency of 50%, while the purpose of the LONGRUN project, launched at the start of January 2020, is to develop a complete range of powertrains for more environmentally-friendly heavy trucks and coaches, with the integration of combustion systems adapted to low-CO₂ fuels (hydrogen, dual-fuel or biofuels).

In addition, working with an industrial partner, research has been conducted to develop innovative systems to reduce pollution in exhaust gases and thereby significantly reduce emissions from vehicles fitted with an IC engine, particularly when operating in an urban setting.

Lastly, IFPEN continues to work with PSA and Renault on pre-competitive research in the field of powertrains within the Groupement scientifique moteurs (GSM).

HIGHLIGHT**THE HORIZON 2020 SUREAL-23**

“Understanding, measuring and regulating sub-23 nm particle emissions from direct injection engines including real driving conditions” project concerned the development of new onboard technologies capable of measuring ultrafine (up to a diameter of 10 nm) particle emissions from gasoline and diesel engines, in real use conditions. This provides the European regulator with a scientific basis for a potential reduction in the regulatory particle measurement threshold from 23 nm to 10 nm.

**HIGHLIGHT****IFPEN’S RECOGNIZED EXPERTISE IN THE MEASUREMENT OF VEHICLE EMISSIONS**

In 2019, IFPEN, as an expert in the characterization of vehicle pollutant emissions, and the French Ministry for the Ecological and Inclusive Transition (MTES) launched a study to evaluate real-use pollutant and greenhouse gas emissions for vehicles complying with the Euro 6d-TEMP standard. This study, the results of which will be published in the last quarter of 2020, will make it possible to provide citizens with a transparent picture of the environmental performances of currently available gasoline, diesel and hybrid vehicles.



Find out more
(only in French).

NEW ENERGIES

Tackling climate change and moving the energy sector to a sustainable, low-carbon and cost-effective energy mix depend on technological innovations. IFPEN is contributing to this transformation by developing production processes for advanced biofuels, bio-based products and plastics recycling processes. IFPEN is also working on CO₂ capture and storage solutions, on ocean energies and energy storage.



Developing the biorefinery for more sustainable products

R&I activities relating to biofuel production currently concern the development of production technology for advanced biofuels (so called “second generation”), using non-food biomass. IFPEN’s research, which concerns the entire process chain, covers the two main routes for converting biomass into fuel: biotechnological (bioethanol production) and thermochemical (biokerosene and biodiesel production). In addition, against a background of a growing demand for more sustainable consumer goods and the risk of a deficit in the global supply of some intermediates, IFPEN is working on the development of processes, catalysts and biocatalysts for the transformation of biomass into bases for the chemicals sector.

HIGHLIGHT

BIO-BUTADIENE: LAUNCH OF THE 1ST INDUSTRIAL DEMONSTRATOR

In September 2019, Michelin, IFPEN and Axens announced the construction of the first industrial demonstrator in France for the production of butadiene using ethanol coming from biomass, as an alternative to petrochemical-based butadiene. Objective: to manufacture innovative and more environmentally-friendly synthetic rubbers. Work to construct the industrial demonstrator began at the start of 2020 and will be completed at the start of 2021 on Michelin’s Bassens site (Gironde, southwestern France). This demonstrator will be used to test ethanol derived from various types of biomass, including forestry and agricultural waste. The objective is to validate the process developed by the partners, which will ultimately consolidate the portfolio of green technologies marketed by Axens.



Find out more.

HIGHLIGHT**FUTUROL™ TECHNOLOGY ON THE MARKET! TOWARDS AN ADDITIONAL EX-SITU ENZYME PRODUCTION SOLUTION**

The French Futurol™ project targeting the development of a 2nd generation bioethanol production technology was successfully completed at the end of 2018. Market contacts made by Axens have established a favorable competitive position for the technology on the world stage. 2019 was dedicated to evolving the offer, with an ex-situ enzyme production solution. Tests for the purpose were conducted in the laboratory as well as at the Pomacle-Bazancourt pilot facility in the Marne region of northern France.

**Plastics recycling**

In October 2019, IFPEN launched a research program dedicated to the chemical recycling of plastic waste, in order to reinforce its activities in this complementary field to mechanical recycling and develop sustainable technological solutions to convert this waste into very high-quality recycled monomers or polymers. This reflects society's growing expectations in terms of reducing plastic waste and mass recycling and is in line with public policies relating to the circular economy.

**HIGHLIGHT****TOWARDS THE MANUFACTURE OF 100% RENEWABLE PLASTIC BOTTLES**

In February 2019, Anellotech, IFPEN and Axens announced they had successfully produced bio-based aromatics at Anellotech's TCat-8® pilot plant in Texas, and extracted ultra-pure bio-based paraxylene. This success represents an important step in the project, which will lead to the production of 100% bio-based PET bottles. The next step will be the purification of a larger quantity of paraxylene, which will enable Anellotech to produce renewable PET resin to manufacture 100% bio-based bottle prototypes. This will be the first industrial unit dedicated to the production of bio-PET from non-food biomass. With this project, IFPEN is contributing to the development of innovative solutions in the field of bio-aromatics, in line with its strategy aimed at developing renewable chemicals and fuels from non-food biomass.

HIGHLIGHT**CHEMICAL PET RECYCLING**

IFPEN is pursuing the development of a chemical recycling process for opaque and colored PET via depolymerization via glycolysis and purification (decolorization, etc.) to enable its re-use for bottles. The samples obtained at small pilot scale are satisfactory in terms of quality (color, purity, etc.) and a process scheme has been established. Tests currently under way are aimed at consolidating results at large pilot scale before moving forward to the demonstration step.



Find out more.





ALEXANDRE SAUVAGE
CEO,
Leosphere

“Leosphere, the global leader in wind measurement using lidar technology, is an SME based in Saclay. Following the joint work conducted within the framework of the ANR SMARTEOLE project with ENGIE Green, in particular, we signed an exclusive bilateral research agreement with IFPEN relating to the development of several technological building blocks geared to wind turbine control using lidar.

This partnership led to the development by IFPEN of a beta version of the WiSe-Windfield software solution that incorporates some major advances compared with the state of the art. The software makes it possible to accurately reproduce the wind field measured by a lidar placed on the nacelle of a wind turbine and will be integrated into systems within the WindCube® Nacelle range aimed at active wind turbine control. A licensing agreement has been drawn up and the software is set to be tested with target customers.”

Targeting new technological markets

To support the industrial development of new energy transition sectors, new R&I themes are emerging. With this in mind, IFPEN is investing in a variety of fields, including eco-efficient critical metal and rare earth production technologies, hydrogen production and storage, geothermal energy and biogas purification. For example, in 2019, a study was conducted focusing on reducing the costs associated with AE-Amine biogas purification technology, led by Arol Energy. Further potential new markets were also identified, such as the treatment of industrial flue gases, the chemical conversion of CO₂ and metals recycling, and will be the focus of new R&I initiatives in 2020.

Offshore wind and ocean energies booming

Offshore wind represents a rapidly developing sector of the future. IFPEN is contributing to this boom, with efforts focused on three main areas: the development of technologies for floating wind turbines hinged around the integrated simulation of their behavior in their environment, the design of more efficient turbine control systems and the development of a range of wind turbine digital twins. The latter incorporate physical models and sensors with a view to optimizing production and maintenance. IFPEN's teams are also contributing to the development of a control solution for efficient wave energy technology that can be used by industry.



Energy storage and management: a unifying program

IFPEN's research is focused on stationary electrical energy storage, targeting the development of high powers and capacities (above the MW and MWh scales). The organization is developing several energy storage technologies such as Adiabatic Compressed Air Energy Storage, and REDOX Flow batteries, as well as energy management systems (EMS) aimed at facilitating the integration of renewable energies into the networks. Research targeting new battery technologies for stationary and mobile applications was also launched in 2019, in collaboration with the Transport technology business unit.



HIGHLIGHT**EMS: 2019, NUMEROUS AVENUES**

In 2019, a number of industrial contracts were secured and the first demonstrations were conducted involving EMS:

- a design study for a hybrid hydro-solar system (pumped storage power plant/floating photovoltaic) was conducted with an industrial partner;
- EMS services involving the remote management of a storage system combined with photovoltaic technology are now operational on the microgrid at the IFPEN-Lyon site. These services include forecasts for electricity production and building's energy consumption. They are hosted in a web platform.

HIGHLIGHT**IFPEN AND TOTAL JOIN FORCES TO SUPPORT THE ROLL-OUT OF CCUS AND ATMOSPHERIC CO₂ REDUCTION TECHNOLOGIES**

On 8 July 2019, IFPEN and Total signed a strategic R&D partnership agreement relating to CO₂ capture, utilization and storage (CCUS) as well as atmospheric CO₂ removal technologies. The agreement covers:

- a strategic research partnership, aimed at reducing the cost of infrastructures and improving the performance of technologies within the CCUS chain in order to enable rapid large-scale deployment. Research priorities include areas relating to new solvents and materials, process intensification, underground CO₂ storage in deep saline aquifers, technical and economic evaluations and the quantification of the environmental benefits for the entire CCUS chain ;
- a "Carbon management and negative CO₂ emissions technologies towards a low carbon future" chair.

Safe management of the underground environment

Drawing on the transfer of E&P technologies to new energies, IFPEN aims at developing solutions for the uses of the subsoil that meet safety and environmental protection criteria and provide optimized solutions in the ecological transition. IFPEN's research is hinged around three fields: geothermal energy, hydrogen and industrial and environmental monitoring. A cross-disciplinary component supports these fields, providing approaches and tools for geological modeling serving the energy transition and underground storage behavior modeling.

Reinforcement of CO₂ capture and storage (CCS) activities

In 2019, IFPEN's teams stepped up their research relating to the CO₂ capture and storage chain, covering the whole CCS chain:

- CO₂ capture in order to provide optimal solutions for this step, which is most often the most expensive one in the CCS chain;
- large-scale CO₂ storage and site monitoring in order to maximize the amount of stored CO₂ while ensuring safety and the long-term viability of the sector;
- CO₂ compression and transport and well management;
- life-cycle analyses and techno-economic evaluations to help public authorities and industrial players evaluate technologies.

HIGHLIGHT**INDUSTRIAL-SCALE CO₂ CAPTURE AND STORAGE: LAUNCH OF THE 3D PROJECT**

In June 2019, a consortium bringing together 11 European players, including ArcelorMittal, Axens, IFPEN and Total, launched a demonstration project for the innovative CO₂ capture process of industrial origin DMXTM. The "3D" project (DMXTM Demonstration in Dunkirk), which is part of the European Union's Horizon 2020 research and innovation program, targets three objectives:

- demonstrate the efficiency of the DMXTM process on an industrial pilot scale;
- prepare for the development of a first industrial unit that could be operational from 2025;
- design the future European Dunkirk - North Sea cluster, which should be able to capture, process, transport and store 10 Mt of CO₂ per year and be operational by 2035.

"3D", which aims to validate reproducible technical solutions and enable the industrial roll-out of capture-storage technology around the world, is an essential lever in terms of meeting the objectives of the Paris Climate Agreement.



Find out more: read the summary of the "CO₂ capture-storage-utilization: a lever for a transition to low-carbon industry" round table (only in French).

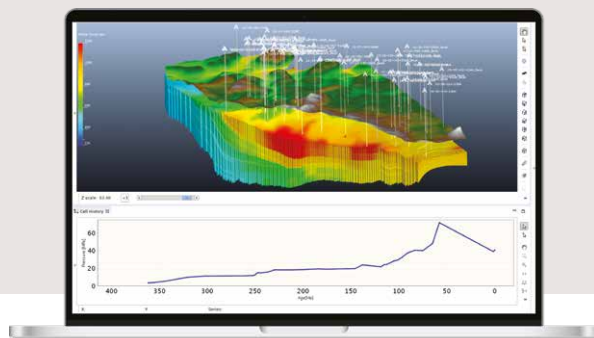
RESPONSIBLE OIL AND GAS

IFPEN's commitment to the development of a sustainable energy mix is reflected in actions aimed at increasing energy efficiency, reducing CO₂ emissions and limiting the environmental footprint of industry and transport while meeting the global demand for mobility, energy and products for the chemicals sector. For example, IFPEN develops eco-efficient and flexible processes for the production of fuels and chemical intermediates meeting the most severe standards. To make better use of reserves, IFPEN also proposes increasingly efficient and cleaner, cutting-edge technologies for oil and gas exploration and production.

HIGHLIGHT

MODELING AS A TOOL FOR UNDERSTANDING EXPLORATION RISKS

Basin modeling is vital in order to identify drilling opportunities, estimate the oil and gas potential of sedimentary basins, locate future fields and reduce exploration risks. Thus, within the framework of the NOMBA project conducted with Total, IFPEN developed the first calculator combining dynamic oil system simulation (ArcTem code integrated in the TemisFlow™ suite) with open-access geomechanics software (EDF's Aster code). This technology, evaluated on Total case studies, proposes increasingly predictive models while maintaining good calculation performances. Among other aspects, it addresses the problem of predicting excess pressure and natural fracturing regimes in sedimentary basins, decisive for the evaluation of their economic potential, drilling dimensioning and well safety.



Understanding and modeling underground environments

Despite a reduction in the share of fossil energies in the energy mix, the reliance on fossil fuels is set to remain at around 40% through to 2040. It is thus vitally important to develop innovative solutions in order to help conduct exploration and production activities in a more environmentally-friendly manner, exploiting only those fossil energies strictly necessary to take us through this transition period, particularly gas.

Knowledge of sedimentary basins and oil and gas reservoirs explored by the oil and gas industry is essential in order to reduce the risks and limit the number of drilling operations while managing the environmental impact. In this context, IFPEN develops solutions for quantitative modelling of the earth's subsurface, risk analysis methodologies and ultra-safe production equipment.

**CLAUDE GOUT**Total Exploration Earth Modeling,
R&D project leader

“IFPEN and Total, long-standing partners in the field of basin modeling, set up an innovative partnership in terms of its design and approach within the framework of the NOMBA project. It is hinged around a multidisciplinary team working in an open-space environment—a definite advantage in terms of project dynamics—and an operational approach focused on needs on the ground as communicated by Total’s exploration teams.

Total has thus provided case studies, including data from the Neuquén basin in Argentina, enabling researchers at IFPEN to develop more realistic three-dimensional basin models with an optimized stress state. This method has proved highly effective since NOMBA has led to patents and the first industrial use globally. The prototype is currently being tested on our Pangea supercomputer.

The project’s success also paves the way for application in the field of new energy technologies, in order, for example, to more accurately predict fluid flow such as hydrogen or CO₂ and define storage targets in saline aquifers.”

5

**new JIPs with
15 industrial partners
launched in 2019**



Improving production with enhanced recovery

Enanced oil recovery (EOR) is of considerable importance to oil companies because it helps meet the demand for oil and gas, producing more from existing reservoirs while increasing the recycling of produced water and reducing the number of drilling operations. To this end, IFPEN, Beicip-Franlab and Solvay joined forces within the EOR Alliance™ to develop technologies and services adapted to different reservoir conditions and all types of EOR process using eco-responsible chemical techniques or hybrid processes combining chemical techniques and CO₂ injection. The integrated solutions provide complete coverage of the chain, from laboratory-scale EOR formulation development to field application. IFPEN’s research also focuses on water cycle optimization in an EOR context to ensure its eco-responsible management.



HIGHLIGHT

WATER CYCLE MANAGEMENT IN AN EOR CONTEXT: TOWARDS A REDUCED ENVIRONMENTAL IMPACT

At the end of 2019, IFPEN, along with six industrial partners, launched the Dolphin 3 JIP dedicated to studying the impact of additives used in chemical EOR on the management of produced water. The ultimate goal is to develop and bring to market an eco-efficient range of solutions, including technologies and services dedicated to the separation of oil effluents, optimized water treatment and the reinjection of produced water. The JIP follows Dolphin 2, the aim of which was to extrapolate, on a semi-industrial pilot scale, phenomena identified in Dolphin 1 in the laboratory.

Offshore production

Offshore production remains strategically important for oil and gas companies. According to estimates, by 2030, it is set to represent one third of global production and half of the oil and gas potential yet to be discovered. Industry still faces a number of challenges that need to be overcome; drilling wells, pumping and transporting fluids to the surface; separating effluents on the sea bed. IFPEN supports the sector's players in these areas, developing efficient and more environmentally-friendly solutions while guaranteeing safety and managing the risks associated with drilling and production.



HIGHLIGHT

A NEW FRAMEWORK AGREEMENT WITH TECHNIPFMC LAUNCHED ON NEW ENERGY TECHNOLOGIES

The framework agreement between IFPEN and TechnipFMC was renewed for a period of five years, in order to pursue the development of technologies relating to reeled flexible and rigid pipes, umbilicals and composite hybrid flexible pipelines. It places the focus on technological innovation to meet the requirements of deep offshore markets in response to the development of fields with increasingly restrictive characteristics.

It will also make it possible to explore new technologies in the energy transition and renewable energy fields, with a view to anticipating industrial evolutions.

7.5 MT

of sulfur removed from atmospheric pollution thanks to the introduction of IMO standards

40 to 60%

of chemical intermediates produced from crude



Heavy crude and residue conversion and purification

The conversion of heavy fractions into light and middle distillates remains essential for two reasons: a sustained and long-term demand for light products combined with the gradual extinction of the low-quality heavy fuel market; an increase of heavy crudes fractioning the global oil supply. IFPEN is thus pursuing the development of processes and catalysts for the conversion and purification of heavy feeds to obtain cleaner products meeting increasingly stringent specifications.

In particular, R&I teams are working on the deep hydroconversion of heavy residue via ebullated-bed hydrocracking with the H-Oil process, allowing conversion rates above 90% for some major feed types. Improvements made to the process have enabled Axens to obtain several references in the field. Schemes based on the H-Oil process are targeting final conversion of heavy crudes primarily for the chemicals sector and the production of cleaner bunker fuels to meet IMO standards (sulfur content of marine fuels below 0.5% from 2020).

HIGHLIGHT

CATALYTIC CONVERSION OF CRUDE OIL INTO CHEMICALS

At the start of 2019, Axens, Saudi Aramco and TechnipFMC signed a collaboration agreement aimed at accelerating the development of Catalytic Crude to Chemicals (CC2C) technology and bringing it to market by 2021. IFPEN's teams are contributing with their expertise in the fields of process modeling and technology extrapolation. This innovative technology for the catalytic conversion of crude oil into chemicals is aimed at increasing efficiency and chemical intermediate yields, converting more than 60% of the crude oil into petrochemicals, while minimizing emissions.

Clean fuel production

In the refining sector, the global tightening-up of regulations governing fuels continues in order to improve air quality, with, for example, the widespread application of the requirement to limit the sulfur content to 10 ppm. Efforts are also being made to optimize oil conversion into chemicals to improve the competitiveness of the existing refining facilities and help them adapt to the future market needs. Thus, IFPEN's research activities are focused on the development of catalysts and eco-efficient processes for the production of clean fuels and the ready-use of the converted products by the chemicals sector. In particular, these activities concern the development of hydro-

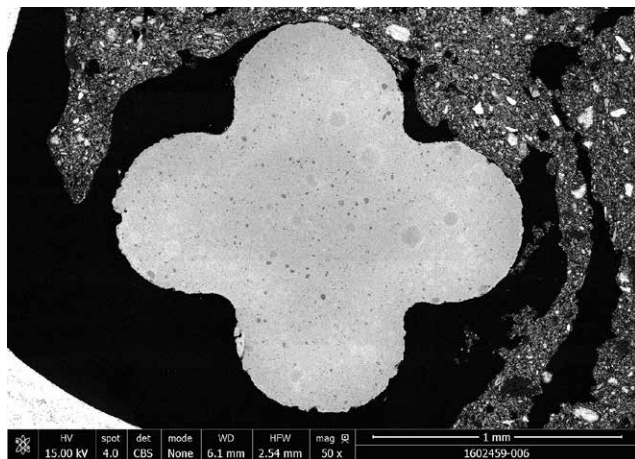
processing for conversion and purification of distillates and catalytic reforming or isomerization technologies for gasoline production. For example, the development of innovative hydrocracking catalysts enabling maximum conversion of heavy distillate to diesel or naphtha market, was finalized in 2019.

In parallel, IFPEN is developing digital technologies aimed at addressing the challenges of the intensification of industrial operations and the optimization of industrial sites performance in terms of energy efficiency (reduction in greenhouse gas emissions), overall efficiency and safety.

HIGHLIGHT

A NEW HYDROCRACKING SOLUTION FOR THE CHEMICALS SECTOR

IFPEN's teams have developed a new, highly-selective hydrocracking catalyst to produce a high yield of naphtha cuts. This achievement is the result of many years of research aimed at designing the combination of acid sites crucial to obtaining its cracking selectivity. This catalyst, which will consolidate Axens' offer in this segment, will address the expectations of industrial players as they seek to maximize the conversion of oil cuts into petrochemical bases while minimizing the fuels produced.



HIGHLIGHT

TOWARDS ENHANCED PROCESS PERFORMANCE IN THE DIGITAL ERA

Data acquisition and exploitation have become essential improvement and performance levers for the refining and petrochemicals sectors. Conscious of this, IFPEN has reinforced its R&I activities aimed at developing a digital offer enabling end users to better exploit and model information generated by commercial units in order to maximize their operational performance. This new digital twin offer is hinged around Connect'In™, Axens' digital process performance modeling platform. IFPEN's research to support the industry's digital transition continues in 2020.



Petrochemical intermediates production

Petrochemical intermediates are used in the production of numerous everyday products, such as plastics. Driven by the increase in demand for consumer goods, growth in the petrochemicals sector is an underlying trend. IFPEN's research is aimed at developing new catalysts, adsorbents and olefin and aromatic production processes while increasing the purity of the products obtained and consuming less energy.

In the field of aromatics, teams pursued their research activities dedicated to the formulation of high-performance adsorbents for the Eluxyl® paraxylene separation process, marketed by Axens, thereby improving its capacity to use new, ultra-efficient xylene separation molecular sieves. Work also continued to optimize the overall paraxylene production complex from an energy and economic point of view.

Concerning olefins, IFPEN improved the selectivity of the homogeneous catalysis process for the production of 1-hexene (AlphaHexol™) from ethylene and developed a new 1-butene production technology based on the dimerization of ethylene. These technologies, marketed by Axens, address the considerable growth in the demand for polyethylene-type plastics.

Natural gas treatment and conversion

IFPEN is actively involved in natural gas purification. Research is primarily focused on natural gas sweetening (removing the carbon and sulfur from the crude gas) in order to meet the specifications required for its use, and to be able to transport it and liquefy it. Having already developed a range of processes, solvents and packings for absorption columns, IFPEN continued its research to improve the performance of gas sweetening processes with a new solvent that will be tested on a large-scale unit.

OUTWARD-LOOKING FUNDAMENTAL RESEARCH SERVING INNOVATION

In order to support its innovation ambitions and ensure the scientific excellence of its research activities, IFPEN draws on a solid fundamental research program, organized around nine scientific challenges. Launched four years ago, this program reached maturity in 2019. It has provided a platform for more efficiently addressing scientific questions raised by the development of new products and processes and reinforcing the collaborative research strategy implemented with its network of partners.

A structured and operational fundamental research system

In 2016, IFPEN formalized the cross-disciplinary reasoning processes associated with its activities in the form of “scientific challenges” covering the entire research process, ranging from the understanding of mechanisms on an atomic scale through to the evaluation of the economic and environmental impact of its processes and products. These challenges are themselves broken down into sub-challenges, i.e., hurdles to be overcome in order to develop innovations. Between projects, PhD theses, post-doctoral research and partnerships, IFPEN channels all its resources into removing these hurdles. Fully operational, this organization structured around challenges consolidates a methodology based on pooling and sharing.

A long-term outward-looking and collaborative approach to accelerate innovation

In 2019, IFPEN pursued its open-door policy towards French and European partners promoting a diverse range of collaboration methods. A stakeholder in consortia with industrial players such as Safran Tech, it also consolidated academic partnerships renewing several framework agreements with other research organizations (INRAE and INRIA) and forged new ones with prestigious universities (British Columbia and Stuttgart). The launch during the year of the first joint research laboratory (Carmen) with the CNRS also helped consolidate IFPEN's positioning in the French Research and Innovation System (SFR). Finally, IFPEN participates in calls for projects launched

by funding bodies such as the ANR and the European Horizon 2020 program.

The increasing recourse to collaboration has made it possible to more effectively direct fundamental research towards strategic priorities dedicated to new energy technologies (NETs), making collective intelligence work for the energy transition. The majority of these are dedicated to new energies and sustainable mobility while collaborative projects with public funding support involving IFPEN reflect its increasing role in new fields of interest (driverless vehicles, geothermal energy, batteries, air quality).



**3 projects supported by the ANR
launched by IFPEN in 2019 and
3 new ITN* / H2020 projects**

* Innovative Training Networks

HIGHLIGHT**CARMEN: THE NEW JOINT RESEARCH LABORATORY WITH THE CNRS**

In 2019, a joint research laboratory (JRL) called Carmen (CARactérisation des Matériaux pour les Énergies Nouvelles, characterization of materials for new energies) was created, bringing together, alongside the CNRS and IFPEN, ENS Lyon, Sorbonne University, Claude Bernard Lyon 1 University and Strasbourg University. The purpose of this new entity is to reinforce knowledge on molecular and/or colloidal transport in complex porous substrates and develop new methodologies for the detailed analysis of these materials in order to support the development of innovations for the energy transition. The collaborative work carried out by these outstanding teams makes the Carmen JRL a unique consortium on the international stage, a platform for the sharing and exchange of know-how and the pooling of high-performance equipment dedicated to the development of knowledge and innovative solutions.



Find out more.

**HIGHLIGHT****CORROSION RESISTANCE: CREATION OF A RESEARCH ALLIANCE**

IFPEN joined forces with seven partners (Axel'One, Institut de la corrosion, CNRS, École des mines engineering school in Saint-Étienne, INSA Lyon, MECM and the University of Lyon) to form the CorRTEx "Corrosion Research, Technology and Expertise" alliance. The alliance's academic and private corrosion partners have invested in a joint facility: a high-pressure and high-temperature corrosion test loop simulating a variety of corrosive environments.

It reproduces extremely harsh operating conditions to test the corrosion resistance of various materials, understand the origin of corrosion damage, predict operating performances and detect corrosion at an early stage. This pooled experimental tool can be used by partners to support industrial customers as well as for collaborative research projects, particularly focusing on problems related to new energy technologies.

**NOALWENN SALLÉE**

IFPEN "Characterization / Verification of soils in the energy and environmental transition" project manager

"Due to their capacity to store carbon, soils have an important role to play in the implementation of the French national low-carbon strategy within the framework of the country's Climate Plan. IFPEN has incorporated this component into its scientific reasoning, dedicating one of the sub-challenges to the understanding of the role of soils in carbon flows between the atmosphere and the geosphere. At IFPEN we have built up expertise to address this challenge, in the fields of organic and mineral geochemistry as well as biotechnology, in particular, and we intend to supplement this expertise with that of our network. Accordingly, we are working to construct new partnerships within the community of soil players. For the "Characterization / Verification of soils in the energy and environmental transition" project, in 2019, we defined the new priority theme "Soils, contribution to climate change mitigation" when we renewed the framework agreement with INRAE. The aim is to improve our expertise and our technologies, including the Rock-Eval® standardized thermal method, dedicated to the analysis of organic matter, with a view to pursuing our objective: establish a reliable and standardized methodology for quantifying organic carbon in soils and more effectively address the needs of the energy transition."



HIGHLIGHT

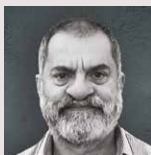
AWARD WINNERS IN 2019...

Céline Pagis received the Yves Chauvin prize and the Denise Barthomeuf prize for the excellence and originality of her work leading to the creation of new zeolite morphologies with better catalytic and transport properties.

Sophie Bernadet, a former IFPEN doctoral student, received a thesis innovation award from the French Chemistry Society's Energy Inter-division for her work on the photoconversion of CO₂ using porous monoliths.

Éric Deville received a prize awarded by the French Isotope Society (SFIS) for the best article written by a French-speaking researcher; the article related to ophiolitic complexes, reaction mechanisms and the formation of seepages at various locations around the world.

Benoît Nœtinger received the Adrien Constantin de Magny prize, awarded by the French Academy of Sciences, in recognition of his career's work and his original research based on the application of mathematical methods to viscous fluid flows in porous and fractured media.



Read about all the awards obtained in 2019.

HIGHLIGHT

ENCOURAGING DIALOG BETWEEN SPECIALISTS ON SCIENTIFIC PROBLEMS SUPPORTED BY INNOVATION

IFPEN's Rencontres scientifiques events and workshops are aimed at enhancing fundamental research by promoting exchange between experts on original themes. They are an opportunity for researchers from different countries and scientific communities to present progress in their research and discuss the latest developments in their specialist fields. In 2019, the Microfluidics Rencontre scientifique event and the Scienc'Innov e3CAV workshop related respectively to the contribution of microfluidics to R&I, from laboratory activities through to new process development, and to the contribution of CAVs (Connected and Automated Vehicles) to mobility sustainability. The renewal of the framework agreement with the INRAE paved the way for the joint organization of the 3rd European bioeconomy conference. In 2019, IFPEN also hosted the annual Mascot-Num conference, covering data assimilation, uncertainty quantification, statistical techniques for machine learning and numerical analysis.



**HIGHLIGHT****AI AND NUMERICAL SIMULATION TO OPTIMIZE RESEARCH**

In 2018, IFPEN initiated an ambitious action plan to drive its digital transformation. 2019 brought further advances within the framework of the plan, aimed at developing new innovations as well as improving the agility and efficiency of R&I processes. In particular, the ACAI (Acceleration of Computations through Artificial Intelligence) project, a component of the challenge relating to the role of AI in numerical simulation, focuses on the application of data sciences to the simulation of physical processes. The idea for IFPEN's teams and their Inria partners is to catalog and categorize the numerous existing approaches that hybridize AI and simulation, and then evaluate them on models similar to their own. The objective is to develop new deep learning methodologies in order to improve modeling and accelerate the simulation of the physical processes at work in porous media, engines, wind turbines, processes and thermodynamics.

HIGHLIGHT**SHARED EXPERTISE AND RESEARCH, IN FRANCE AND AROUND THE WORLD**

In 2019, IFPEN either signed or renewed several fundamental research partnership agreements, with:

- INRAE (French National Institute for Agriculture, Food and the Environment), to work on climate-ground interactions;
- INRIA (French Institute for Research in Computer Science and Automation), in the fields of numerical methods, data sciences and artificial intelligence;
- Safran Tech, for the development of a joint open source platform.

Agreements were also signed on the international stage with the University of Stuttgart (Germany) and the University of British Columbia (Canada).

**HIGHLIGHT****IFPEN'S OPEN ACCESS PUBLICATIONS**

In order to raise the profile and influence of its research, in 2017, IFPEN introduced a policy of open, free and unlimited access (open access) to its researchers' publications and associated data. In this context, IFPEN opted for a green open access approach, self-archiving articles on the HAL-IFPEN platform and supporting its researchers in their publication efforts. In 2019, 75% of articles published in peer-reviewed journals were archived in HAL-IFPEN. This initiative is in line with a French and European drive to encourage the sharing of research results and help speed up innovation.

ENCOURAGING AND SUPPORTING INNOVATION

IFPEN's ambition is to contribute to the development of green industrial sectors and sustainable mobility, and speed up the detection of new energy technology opportunities. To this end, a diversification process is under way concerning industrial partnerships, innovation support for SMEs and start-ups, and the development of IFPEN Group subsidiaries. Underpinning this process, IFPEN has created the internal conditions required to express a genuine innovation culture.

Stimulating internal innovation in the NET field

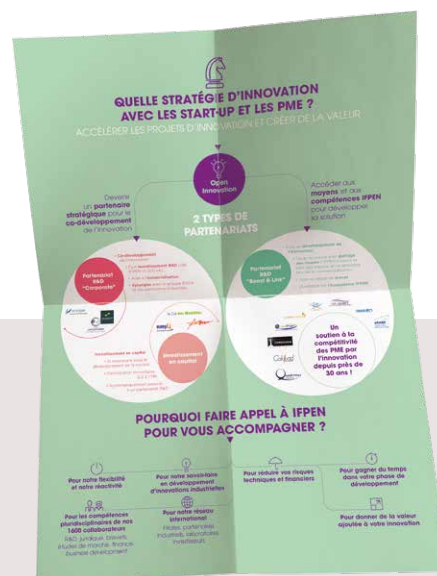
The new energy technology diversification strategy supporting innovation is reflected in IFPEN's organizational structure.

Accordingly, IFPEN has established a project incubator aimed at increasing its contribution to the development of innovative technologies supporting the energy transition and the new associated markets. For example, in 2019, IFPEN examined: ocean photovoltaic energy, the treatment of industrial aqueous effluents, the extraction and purification of biological substances from plants, particle pollution (excluding engines) in urban zones, dynamic aquifer management and urban geology.

In addition, regular innovation challenges aimed at employees, IFP School students and employees of IFPEN Group subsidiaries are organized, stimulating the company's innovation culture in the field of new energy technologies.

Moreover, a "free creativity" initiative operates alongside those described above, focusing on the development of new skills, methodologies and experimental and numerical tools.

Lastly, via its spin-off initiative, IFPEN helps employees seeking to set up their own companies. For example, in 2019, IFPEN helped an employee set up Linkilab, a company offering a service connecting measurement and analysis players with access to specific equipment with customer companies, via a digital platform.



Start-up and SME support

IFPEN has been actively supporting SMEs and intermediate-sized companies for nearly 30 years. Today, this support extends to start-up companies and is primarily focused on the energy transition and the environment. Objective: to create wealth and jobs in the regions by supporting the economic activity and competitiveness of companies driving an innovation project.



**ABDELKRIM
GHERRABTI**
CEO and founder
of Naturamole

“Established in 2003, Naturamole is an SME specializing in the development of bioprocesses and the production of natural molecules via enzymatic biocatalysis and microbiological fermentation, primarily aimed at the agrifoods, perfume, cosmetics and fine chemistry sectors. Thanks to this agreement, IFPEN will be helping us identify and validate a process for producing two highly pure lactones for a launch to market as natural ingredients carrying EC 1334/2008 and COSMOS certification for the formulation of flavorings and perfumes.”



Reinforcing partnerships to improve the detection of opportunities

Via an extensive network of partners, IFPEN identifies collaborative opportunities with SMEs and young innovative companies and optimizes intelligence activities concerning new fields. In 2019, this network was reinforced. IFPEN signed a partnership agreement with Incuballiance, the Paris-Saclay incubator, and InnoEnergy, a European network that supports innovation and business creation in the field of sustainable energies. IFPEN also became a member of two more theme-based accelerators supported by leading national industrial groups: EVOL'EN'UP, in the energy sector, which supports young companies offering new products and services relating to operational efficiency, carbon footprint reduction and responsible energy management, and Plant 4.0 aimed at identifying equipment solutions and innovative services in the field of the factory of the future. These partnerships sit alongside other collaborative initiatives established several years ago with numerous innovation support structures, including Axel'One and Axelera, as well as the Carnot network, the purpose of which is to develop partnership research between SMEs and public research players.

Technological and capital support

Not only do IFPEN's partners have access to its technical resources and the skills and expertise of its researchers in more than 50 disciplines, but also to its entire ecosystem and network of players. In 2019, IFPEN signed an R&D partnership agreement with Naturamole, an SME specializing in the production of natural molecules via enzymatic biocatalysis and fermentation, and developed an algorithm for detecting pipeline damage within the framework of the partnership with Spade Pipelines, an Île-de-France-based SME specializing in the real-time detection of such damage.

The long-term R&D partnership established with some innovative young companies may be supplemented with the acquisition of stakes in the companies in question.

HIGHLIGHT

200 IDEAS EMERGE IN THE INTERNAL INNOVATION CHALLENGE

A new edition of the internal innovation challenge was launched in October 2019. Objective: to generate projects covering all activities relating to IFPEN's new fields. For this challenge focusing on the environment and climate, participants were asked to submit proposals in four categories: the factory, the town/city, the sea and the planet. More than 200 innovation ideas were submitted. The intermediate jury pre-selected 15 ideas, which teams must now further develop and structure before submission to the final jury, when five or six winners will be designated.



Supporting the Group's subsidiaries and shareholdings in their new energy technology adventure

IFPEN's technology transfer policy is underpinned by its dynamic portfolio of subsidiaries and stakeholdings, today bringing together reference global industrial players (Axens, Beicip-Franlab, IFP Training, etc.) and newly-created innovative companies such as DriveQuant and La Compagnie des Mobilités. This model addresses the current need for the creation of sectors in the fields of new energies, the environment and sustainable mobility. Hence, in line with R&I activities, the Group's subsidiaries are pursuing their new energy technology development.

More than 250 new innovative start-ups and SMEs were identified by the Incubation and SME division's team in 2019. Around 50 of these held further discussions with an IFPEN Business Unit. These discussions resulted in around 10 R&D partnership contracts.



ÉRIC BENAZZI

Vice-President, Marketing & External Communications, Axens

"There is increasing competition in new energy markets and in an energy transition marked by changes and breakthroughs, it is crucial to remain competitive and identify our sustainable growth levers of the future. The partnership with IFPEN's researchers enables us to permanently reinvent ourselves and helps us identify our growth levers, particularly in the new energy technologies field."

HIGHLIGHT

IFPEN ACQUIRES A STAKE IN THE SMART ELECTRIC TRAILERS AND TROLLEYS SPECIALIST

IFPEN acquired a 10% stake in K-Ryole, a company specializing in smart electric trailers and trolleys. K-Ryole™ effortless traction technology enables professionals to transport heavy loads weighing hundreds of pounds, by bicycle or on foot, without feeling any weight behind them. Launched in March 2016, the first smart trailer for bicycles cancels the weight transported thanks to its self-regulating motors, thereby reducing the environmental footprint of urban logistics. In October 2018, K-Ryole adapted its technology for the construction sector with the creation of Kross, a smart electric trolley. K-Ryole has won more than 40 awards for its innovation in recognition of a rare potential in the bike tech sector.

"This investment will be accompanied by a technological partnership with IFPEN enabling K-Ryole to develop its range. With this new acquisition, IFPEN also reinforces its positioning as an innovation player supporting soft mobility", adds Nathalie Alazard-Toux, Director of IFPEN's Industrial Development Business Unit.



Visit LinkedIn to follow the adventures of the smart trolley.

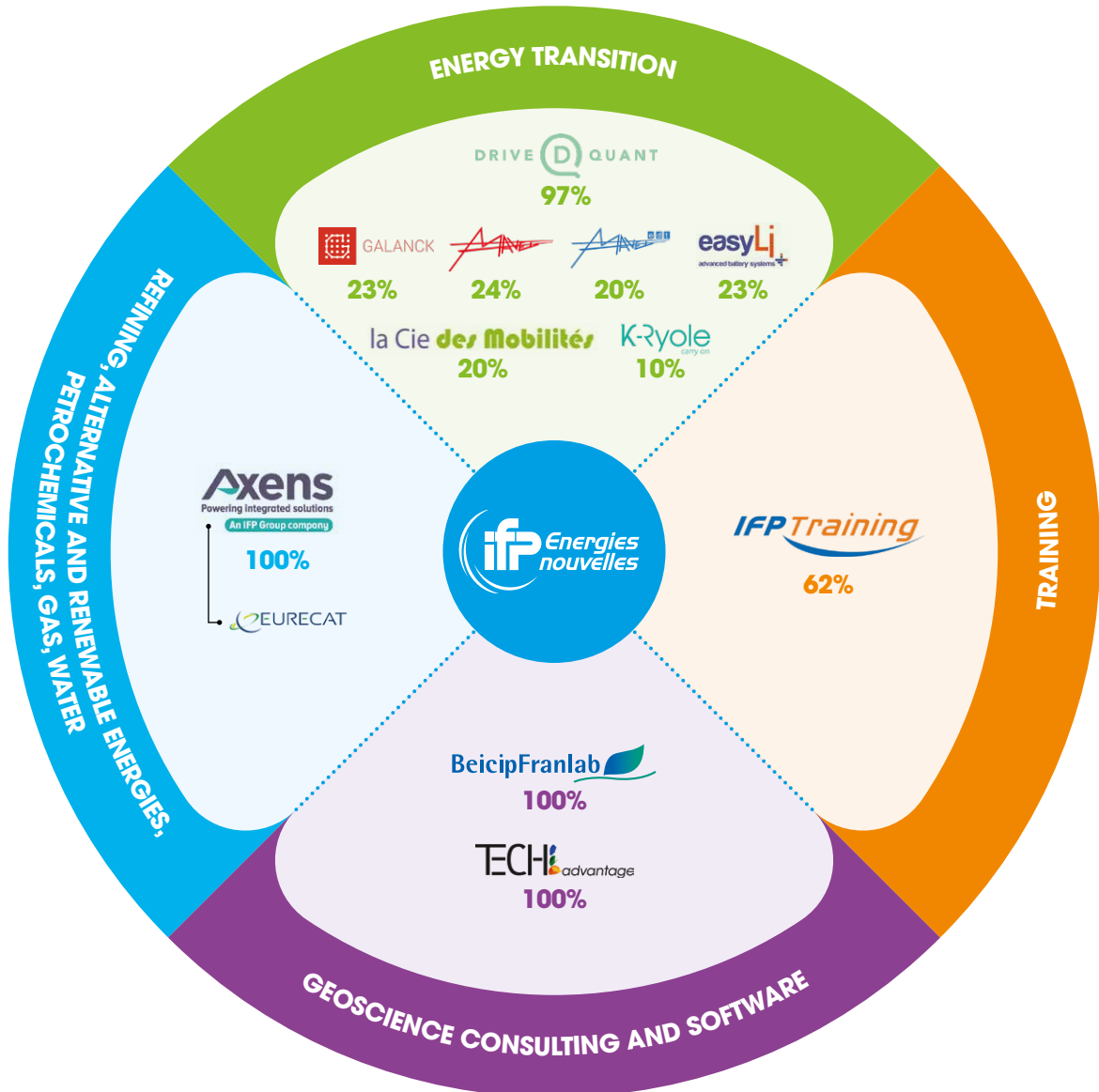
HIGHLIGHT

A SUBSIDIARY WITH A MISSION TO IMPROVE BEHAVIOR BEHIND THE WHEEL

An innovative group company established in 2017, DriveQuant provides driving analysis solutions aimed at improving behavior behind the wheel and optimizing vehicle use. At the end of 2019, DriveQuant reached a new milestone with the launch of Léa, a mobile app dedicated to corporate road safety. Employees are given scores, coaching and challenges to raise their awareness about the dangers of using smartphones at the wheel and helped to adopt a safer driving style. This solution addresses the expressed needs of small and medium-sized companies without the resources to install telematic devices in their vehicles. Early usages demonstrated that the app may significantly reduce incidents or risky behavior (by between 20 and 30%, according to the results of a driving challenge conducted in several companies).

PORTFOLIO OF INDUSTRIAL STAKEHOLDINGS

at 31 March 2020



IFPEN GROUP CONSOLIDATED
ACCOUNTS in 2019

€1,152.3 MILLION

Turnover

€68 MILLION

EBIT

€40.7 MILLION

Net profits Group share



TRAINING

THE KEY PLAYERS IN THE ENERGY TRANSITION

Training is one of IFPEN's statutory missions. IFP School, its applied graduate education institution, provides industry with the highly qualified personnel it requires, delivering teaching programs addressing the challenges of the energy transition and preparing the future architects of this transformation. IFP School thus provides young engineers with advanced graduate programs in the fields of energy and sustainable mobility, based on a resolutely innovative teaching model. It is also supported by a strategic ecosystem of academic and industrial partners in France and around the world.

Securing the long-term recognition of world-class graduate programs

Recognition of the outstanding level of graduate education at IFP School is reflected in the recent accreditation to award Master's degrees (decree of 29 March 2019 in the JORF, the Official Journal of the French Republic). A new accreditation was also delivered by the French National Engineering Accreditation Board (CTI) to award specialized engineering degrees for a period of five years (the maximum period). It covers all training programs, broken down into four broad themes: "Powertrains and sustainable mobility", "Energy economics and management", "Processes for energy and chemistry" and "Georesources and energy".

IFP School trains the future experts of the professions of tomorrow associated with the energy transition, sustainable mobility and digital technology, continuously adapting its course content to the major industrial and societal challenges, while ensuring the continuity of programs linked to its long-standing fields of interest. This is reflected in the consolidation of programs to train specialists capable of managing all the data acquired in the exploration and production of natural resources, particularly oil, natural gas and water. Fundamental changes have also been made to powertrain programs, with an increased focus on electrification and hybridization, in order to address industry's evolving requirements in terms of expertise.

IFP SCHOOL LEADS 4 

teaching and research chairs

9 

prizes awarded to IFP School students

HIGHLIGHT**IFP SCHOOL MOOCs:
A CONFIRMED SUCCESS**

The two first sessions of the new MOOCs organized by IFP School: “Tomorrow’s Mobility” and “Energy Transition: Innovation Towards a Low Carbon Future” attracted more than 30,000 participants in more than 100 countries. Around 20% of students who began their course in September 2019 at IFP School stated that the MOOCs were a factor that encouraged them to apply to the School. A new enhanced version of these online training modules is proposed in 2020.

Firmly rooted in the world of tomorrow

The School is evolving to reflect the expectations of new generations of students. A modernization process hinged around a major participative project bringing together teaching staff, students and alumni, including the provision of infrastructures and tools promoting collaborative work; innovative educational options with, for example, personalized training paths, micro-learning units within programs, the introduction of a Hackaton for the end-of-studies module, and the development of soft skills. These components have been integrated into IFP School’s teaching model, which focuses on solving concrete problems, with a view to effectively preparing students to integrate the workplace. For several years now, IFP School’s educational teams have been developing and using methods promoting the acquisition of know-how and learning through experimentation: flipped classrooms, serious games, virtual and augmented reality, MOOC, etc. New initiatives have already been launched in 2020 with, for example, the creation of a virtual reality laboratory.

**HIGHLIGHT****INNOV'ACTION CHALLENGE**

For IFP School’s 1st Innov’Action challenge, 18 teams of students tackled challenges set by partner companies including Air Liquide, Arkema, Axens, Renault Sport Racing, Technip and Total. The two-day event, forming part of the Experience Sharing Module, enabled students from the class of 2019 to work on the themes of innovation, digital technology and the intercultural dimension within companies.

**Reinforcing the
School’s influence**

IFP School’s dynamic development approach contributes to its international influence. In 2019, ten exchange agreements were signed with universities outside France. The first session of a joint master’s program with the National University of Singapore (NUS) dedicated to cutting-edge technologies and innovative concepts in the offshore sector was launched. Agreements were also signed for two new off-site degree programs, in partnership with IFP Training, for launch in 2020: one in Senegal with the Institut national du pétrole et du gaz (INPG, National Oil and Gas Institute) and the other in Ivory Coast with the Institut national polytechnique Félix Houphouët-Boigny (INP-HB). These examples illustrate IFP School’s strong positioning and international reputation as a leading trainer of energy industry players. New academic partnerships will be established in 2020.

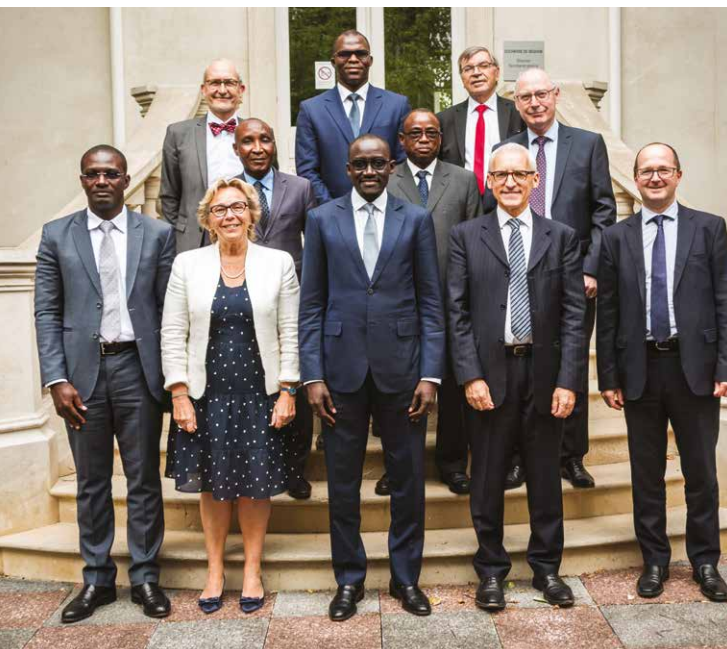


Watch the
Hackaton movie.



HIGHLIGHT**LAUNCH OF THE PETROLEUM PROJECTS AND OFFSHORE TECHNOLOGY MASTER'S PROGRAM IN SINGAPORE**

The first session of the joint Petroleum Projects and Offshore Technology Master's program, the fruit of a partnership between IFP School and the National University of Singapore (NUS), was launched in August 2019. In a context of the rising global demand for energy, this new graduate program is aimed at addressing industry's needs for cutting-edge technologies and innovative concepts while focusing on the issues of safety and environmental impacts. Lasting 16 months, it covers the fields of oil and gas engineering and offshore technologies. It is delivered in English at the NUS campus in Singapore. A second session is already planned in 2020.

**ABDOURAHMANE CISSÉ**

Ivory Coast's Minister for Oil, Energy and Renewable Energies - IFP School Petroleum Economics and Management class of 2005

"In November 2019, we signed an agreement with IFP School and the Institut national polytechnique Houphouët-Boigny (INP-HB) in Yamoussoukro, paving the way for the creation of the École supérieure du pétrole et de l'énergie (ESPE, the oil and energy engineering school).

The creation of this school within an excellence cluster (INP-HB) will give students in Ivory Coast with five years of higher education or equivalent access to additional high-quality training leading to advanced qualifications recognized in the oil and energy sectors.

The 16-month programs, due to be launched in September 2020, will be taught in English. Two programs will be offered: one in the field of oil and gas exploration and production, the other in the field of oil and gas conversion and oil product distribution.

Students will be awarded a double INP-HB / IFP School degree. The ESPE is a component within our country's strategy aimed at ensuring everyone in Ivory Coast, irrespective of social background, has access to affordable, high-quality training."

HIGHLIGHT**IFP SCHOOL LEADS FOUR TEACHING AND RESEARCH CHAIRS**

Over a number of years now, IFP School has been developing a strategy aimed at promoting its research activities, particularly via teaching and research chairs. Currently, there are four active chairs: “Economic modeling applied to the environment and energy”; “Electricity Economics and the Digital Transition” (EEDT); “Electric, Connected and Autonomous Vehicles for Smart Mobility” (ECAV) launched in 2019, and the most recent “Carbon Management and Negative CO₂ emissions technologies towards a low carbon future” (CarMa). The latter, created with the support of Total and the Tuck Foundation, concerns the development of innovative solutions to reduce atmospheric CO₂ emissions caused by human activities.

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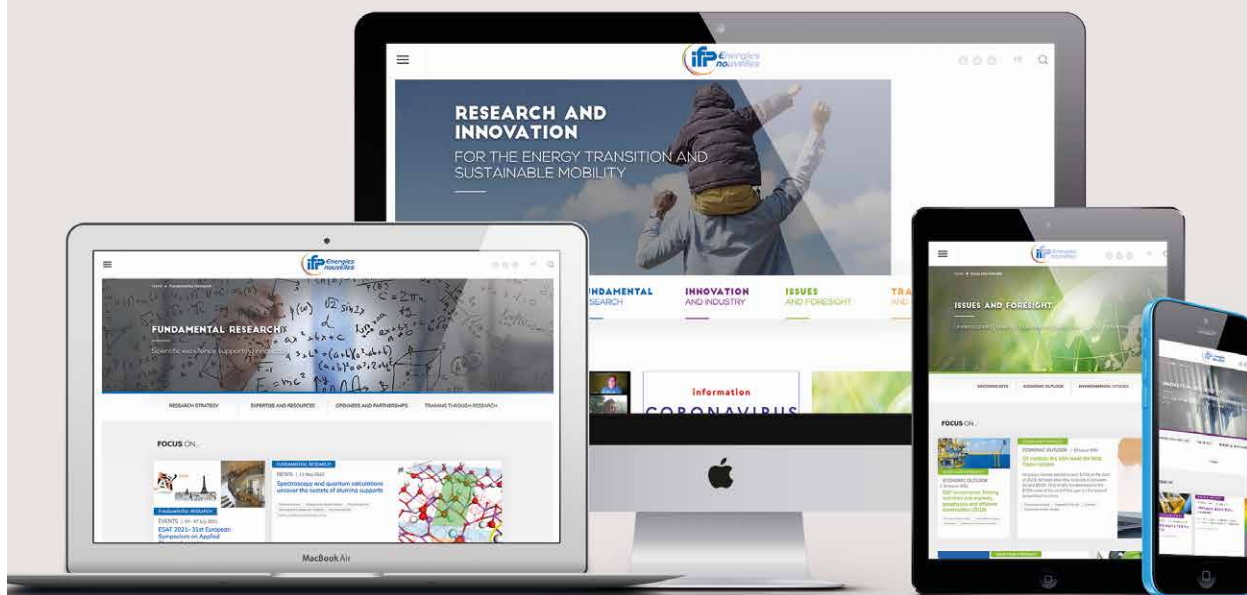
* As of 1 March 2020

IN 2019...

A NEW WEBSITE FOR IFPEN

1.000

visitors per day to
IFPEN's new website
launched in March 2019



IFPEN's new website went online in March 2019. It can be accessed via any device (computer, tablet, telephone).

The site is divided into five sections:

1 "Who are we?"

General information about the organization, its areas of expertise and its organizational structure;

2 "Fundamental research"

IFPEN's fundamental research strategy supporting innovation and presentation of the partnership ecosystem with academic and industrial research players in France, Europe and around the world;

3 "Innovation and industry"

Presentation of IFPEN's innovation model and its range of expertise and technological solutions aimed at

industry to support the transition towards a more sustainable energy mix;

4 "Issues and foresight"

Decoding keys and technical and economic analyses to gain a better understanding of the energy and environmental issues of the 21st century;

5 "Training and careers"

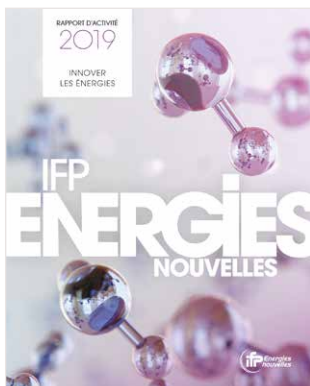
Presentation of IFPEN's training provision for the development of expertise (training through research, graduate programs via IFP School, life-long learning via IFP Training) and job vacancies.



Go to
www.ifpennergiesnouvelles.com

To keep up with all IFPEN's news,
you can also follow us on Twitter, LinkedIn and YouTube





IFP Energies nouvelles
1 et 4, avenue de Bois-Préau
92852 Reuil-Malmaison Cedex
Tél. : + 33 1 47 52 60 00


IFP Energies nouvelles-Lyon
Rond-point de l'Échangeur de Solaize
BP 3 – 69360 Solaize
Tél. : + 33 4 37 70 20 00

www.ifpenergiesnouvelles.com

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MEETING TOMORROW'S CHALLENGE TODAY

IFP Energies nouvelles

is a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities.

